MEASURING VISIBILITY.

By ALFRED H. THIESSEN, Meteorologist.

[Dated: Weather Bureau, Baltimore, Md., May 28, 1919.]

Visibility is the quality or state of being visible, and the visibility of any particular object depends in general upon the intensity of light reflected from the object toward the eye and the distance of the object from the eye.

The intensity of light varies during the day and during the year, and also varies according to the transparency of the atmosphere depending upon the presence of haze, smoke, fog, dust, rain, snow, and changes in the indices of refraction in sections of the atmosphere between the object and the observer.

This element of visibility is very important to aviators and gunners. It is important to know the visibility at night as well as by day, as aviators may desire to travel at night and even to land, and the intensity of lights at the landing field, and the efficiency of light thrown by flares depends upon the visibility.

There would, upon first consideration, seem to be very little difficulty in measuring visibility, because the observer is simply measuring how far he can see. But there are really many difficulties in the work, which will be reviewed in order.

The observers having objects located at definite intervals from the point of observation are trying to measure how far they can see. Leaving the personal equation out of consideration for the moment, they may determine either (1) the farthest object they just can see, or (2) the one that is just outside the range of vision. If they choose the first (1) method, then it is a question of how well the object should be seen, and if one should be able to see any of the details, as for instance the windows of a house.

During the late war the French used a scale of visibility which, with slight modifications, was adopted by the Meteorological Section of the United States Signal Corps. The modified scale of visibility was:

	Kilometers
Very poor	0 to 2
Poor	2 to 5
Fair	5 to 10
Satisfactory	10 to 15
Good	15 to 20
Excellent	20 to 25

In this scale the visibility was said to be "Satisfactory" if one could see objects 10 to 15 kilometers away, and so on, with the remainder of the scale.

The above scale has been superseded (Jan. 1, 1919) by the following scale of surface visibility, adopted by the Meteorological Office of London, the Admiralty Meteorological Service, the Meteorological Service Royal Air Force, and the French Army Meteorological Service:[1]

Visibility scale.	Objects not visible in good daylight beyond—	
	Meters.	Miles.
0. Very bad	200	0.1
1. Bad	500	.3
2. Very poor	1,000	.6
3. Poor	2,000	1.2
4. Indifferent, ordinary	4,000	2.5
5. Fair	7,000	4.3
6. Good, above ordinary	12,000	7.5
7. Very good, unusual	20,000	12.4
8. Exceptionally good	30,000	18.6
9. No report (for telegraphic use)		
	Objects visible in good daylight beyond—	
10. "V" of Beaufort notation	30,000	18.6

[1] From Met. Off. Circ. 32, Feb. 1, 1919, p. 3.

In this scale the limits are carried out farther, which is certainly necessary in the lower limits of the scale, as in the case of the existence of fogs.

It has been the practice in measuring visibility to select objects found in the landscape, as barns, houses, trees, woods, lighthouses, etc., and it has been suggested that the typical objects subtend a vertical angle of 10′ and a horizontal angle of 2½′.

The practical objections to selecting objects at random are that they will differ in shape and color, do not lie in one line of sight, and do not have the same background. A white house can be seen farther than a brown house, both having the same size and shape and both being in nearly the same line of sight. The visibility of either will depend greatly upon its background. Two objects exactly alike as to size, shape, and color, but one lying to the north and the other to the south, will be visible to different degrees. Another difficulty in using objects found in the landscape is that the observers become skillful in discerning what they are looking for, and if transferred to another station, where the objects will in all probability be different, they will, at the beginning at least, make observations not comparable with those made at their previous stations.

To overcome these objections, one may have a series of specially constructed targets, each series being alike for all stations. These targets may be a white circle painted upon a dark background, or any other specially designed object which may prove best for the purpose. The series at all stations should preferably lie to the north. The individuals of a series at a station will differ only as to size, which size should be determined by the angle which they should subtend. This will probably prove expensive, and a single target may be made to serve the purpose, and in many cases may be necessary, as it is extremely difficult to arrange a series in the same line of sight on account of intervening ravines, valleys, or hills.

This single target should be placed at 200 meters from the point of observation. It may be viewed through smoked glasses having 8 degrees of transparency. The smoked glasses take the place of sections of dusty atmosphere and may be so selected that measurements made on the standard object 200 meters away will be comparable to measurements made with the naked eye on objects placed at various distances from the point of observations. For example, if object is visible to the naked eye and not through glass No. 1 the visibility is "bad." If the object can be seen with No. 6 but not with No. 7 then the visibility is "good."

Another method is to observe the target with a telescope so built that its power can be changed rapidly and as many times as there are degrees to the visibility scale. A suitable target would be one with a white background hatched with black lines. This target at a proper distance will appear gray, but if a telescope with sufficient power were used the individual lines would be discerned and the measurement would correspond to a certain degree on the visibility scale.

Observers are called upon to measure visibility at all hours of the day and night, and leaving out of consideration the transparency of the atmosphere, the intensity of light will vary from bright sunlight to the pitchy darkness of a cloudy night, and during the year from bright summertime to the darker days of winter.

In measuring visibility during the 24-hour day the following factors should be applied, owing to the variations in seeing mentioned in the preceding paragraph:

First. Angle of light rays illuminating the object or target.

Second. Condition of sky as to cloudiness, twilight starlight, and moonlight.

At nighttime visibility may be measured by observing several lights in a row, the lights to be screened by glasses having varying degrees of transparency; or a single light could be used, the observer peering through smoked glasses at the point of observation. Experiments are now being made to develop a standard visibility measurer in which a screened light is viewed through glasses of differing opaqueness.

THE AURORA OF MARCH 7-8, 1918.

By HERBERT LYMAN and CHARLES F. BROOKS.

[Dated: Weather Bureau, Washington, July 3, 1919.]

SYNOPSIS.—After discussing auroral phenomena in general, including types, latitude variation, periodicity, height, and cause, this article describes the principal features of the remarkably brilliant aurora of March 7-8, 1918, and presents a large number of detailed accounts by observers in the United States.

A chart of the United States shows places from which reports of the aurora were received. To facilitate intercomparison the descriptions have been grouped and discussed by latitude belts of 2½° each, for as would be expected, the display was pretty much the same at the same latitudes.

The aurora became visible at dusk, March 7 and attained its greatest brilliance, generally, at 9:30 p. m. (90th Meridian Time). Since no display is homogeneous, however, there are variations in the times of greatest brilliance and in the appearance of details of the display, although there is general unanimity concerning the times, colors, brilliance, and aspect, among widely scattered observers. The descriptions of the positions of arches, particularly of a prominent red one, make it obvious that the actual location of the aurora is the factor which determines its aspect, and the distance to which it can be seen, while the lack of streamers in the display at most southern points show that the clearness of the air limits its visibility.

It seems that the magnetic disturbance accompanying this aurora was a repetition, after three 27-day intervals, of the large magnetic storm of December 16-17, 1917. There was a considerable disturbance on January 12, and a minor one at the end of the next 27-day interval in February. Auroras on April 4, 5, and 6, marked the end of this strong series, which was probably caused by 5 successive presentations of an active area on the sun.

INTRODUCTION.

Auroras have always excited widespread interest not alone because of their wonderful formation and beautiful coloring but also because of their very mysteriousness. A superb example of the aurora was that which occurred on the night of March 7-8, 1918. This aurora was witnessed simultaneously over practically the entire North American continent and in Europe. In the United States auroras are not often seen south of latitude 40°, yet in this instance the phenomenon was observed as far south as Miami, Fla., where the observer described it as "a brilliant illumination of the northern sky." Aside from the unusual geographical extent of this auroral display, the most noteworthy features were its brilliance, coloring, and extent over the sky. Several observers said the light from the aurora equalled the light from the full moon. The coloring was magnificient. Various shades of red were generally observed as well as greens and the usual yellows and white.

Reports and notes on the aurora of March 7-8, 1918, received from a large number of regular and a few coöperative Weather Bureau stations, where the sky was not obscured (see fig. 1), also a few reports from observers in other parts of the world, have been assembled and tabulated in groups by latitudes.

It is hoped that these descriptions may be usable for any studies of the geographic synchronism of the times of great brilliance, and for comparisons of the times of occurrence and appearance of particular features as seen at different places. There is such a mass of detail, however, that it may be best to precede the local descriptive matter with (1) a general discussion of the aurora polaris as to its essential features and probable cause, (2) the inferred make-up of great auroral displays, and (3) a summary of the principal features of the aurora of March 7-8, 1918.

AURORA POLARIS.[1]

By W. J. HUMPHREYS.

The aurora polaris is a well-known but imperfectly understood luminous phenomenon of the upper atmosphere. * * *

Types.—While no two auroras are exactly alike, several types have been recognized, such as arcs, bands, rays, curtains or draperies, coronas, luminous patches, and diffuse glows. The arcs normal to the magnetic meridian, often, but not always, reach the horizon. Their under edge is rather sharply defined, so that by contrast the adjacent portion of the sky appears exceptionally dark. The rays, sometimes extending upward from an arch, at other times isolated, are parallel to the lines of magnetic force. Many auroras are quiescent, others exceedingly changeable, flitting from side to side like wandering searchlights, and in some cases even waving like giant tongues of flame.

Latitude variation.—The aurora of the Northern Hemisphere occurs most frequently, about 100 per year, at the latitudes 60° (over the North Atlantic and North America) to 70° (off the coast of Siberia). Its frequency appears to be less within this boundary, while with decrease of latitude it falls off so rapidly that even in southern Europe it is a rare phenomenon. At the same latitude it is distinctly more frequent in North America than in either Europe or Asia.

The distribution of auroras in the Southern Hemisphere is not so well known, but it appears to be similar, in general, to that of the northern.

Periodicity.—It is well established that on the average auroras are more numerous during years of sunspot maxima than during years of spot minima. They also appear to be more numerous before midnight than after. Relations of frequency to phase of the moon, season, etc., have also been discussed, but with no conclusive results.

Color.—Many auroras are practically white. Red, yellow, and green are also common auroral colors. Some streaks and bands are reddish through their lower (northern) portion, then yellowish, and finally greenish through the higher portions. Much of the light is due to nitrogen bands, but the source of the most prominent line of the auroral spectrum, λ .557μ (green), is not known. It has often been attributed to krypton, but other conspicuous krypton lines are absent; besides krypton is too heavy to exist at auroral heights in sufficient abundance to produce a spectrum of such brilliance.

There is good evidence that this green light, the light that produces the "auroral line," is always present in the sky, though whether wholly of auroral origin, or due in part to bombardment by meteoric dust, or to some other cause, is not known.

Height.—The problem of the height of auroras has often been investigated, but only recently solved. By simultaneously photographing the same aurora from two stations against a common background of stars, and measuring the parallax obtained, Störmer[2] and Vegard and Krogness[3] have secured many excellent height measurements. The upper limits of the auroral light vary from about 100 kilometers to over 300 kilometers; and the lower limits from perhaps 85 kilometers to 170 kilometers, with two well-defined maxima, one at 100 kilometers, the other at 106 kilometers.

[1] Quoted from "Physics of the Air," Journ. Franklin Inst., Oct., 1918, pp. 481-484.
[2] Terr. Magnet. and Atmos. Elec., 1916, 21; p. 157.
[3] Terr. Magnet. and Atmos. Elec., 1916, 21; p. 169.